INTENSIFIED *NIAGARA* LEAF FILTRATION VIA IN-SITU ULTRASONIC WAVE FIELDS

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Abstract – Niagara Leaf Filter unit is commonly used for the separation of bleaching agent from the 'Refined Bleached Deodorized' (RBD) oil in the edible/vegetable oil industry. In general, the time required to separate 500 kg bleaching agent from the treated oil is approximately 2 ½ hours after which the system is totally filled with solid particles and the system needs to be regenerated. A typical regeneration process of the system takes approximately 1½ hours. The sequence of filtration and regeneration process is repeated for approximately two to three weeks, depending on the condition of the filter medium, before a thorough cleaning method is conducted which last for a period of five to seven days. In view of the long downtime of the filtering operation system, this study is conducted to investigate the possibility of intensifying the filtration operation with the assistance of ultrasound wave fields. In this paper, the effect of ultrasound on the rate of filtration of activated clay in oil suspension is presented. The degree of filtration rate enhancement as a function of solids concentration in the feed is also discussed. In general, the ultrasound field improves the filtration rate by minimizing the thickness of the filter cake, and hence reducing the resistance of fluid flowing through the filter medium. The solids concentration has a negative impact on the degree of filtration improvement as a result of ultrasound wave fields.

Keywords: Ultrasonic Wave Fields, RBD Oil, Filtration, *Niagara* Leaf Filter

INTRODUCTION

The separation of solids from a suspension in a liquid by means of a porous medium or screen, which retains the solids and allows the liquid to pass is termed filtration[1]. In general, the pores of the medium will be larger than the particles, which are to be removed, and the filter will work efficiently only after an initial deposit has been trapped in the medium. Filtration in the edible/vegetable oil industry is an important unit operation for the separation of bleaching earth from the treated oil. *Niagara* Pressure Leaf Filters are most commonly used for this purpose. *Niagara* Pressure Leaf Filters are based on principle of depth filtration similar to sand filters, but with a layer which is usually only a fraction of one inch deep instead of the sand depth of some 24 inches or more in the sand filters[2].

During operation, the rate of filtration decreases progressively as a result of filter cake build-up on the surface of the filter medium. The process comes to an end when the whole chamber is filled with solids, normally about 2 ½ hours (for standard size filter) after separating 500 kg of solids from the treated oil. The system requires a regeneration process which normally takes about 1 ½ hours. The sequence of filtration and regeneration process is repeated for approximately two to three weeks, depending on the condition of the filter medium, before a thorough cleaning method is conducted which last for a period of five to seven days.

Looking at the whole filtration operation, in a day (24 hours), the system only able to perform 4 cycles of filtration. This is equivalent to 3000 kg of solids separation per day. In view of the long downtime and a slow filtering operation system, this study is conducted to investigate the possibility of intensifying the filtration operation with the assistance of ultrasound wave fields. In this paper, the effect of ultrasound on the rate of filtration of activated clay in oil suspension is presented. The degree of filtration rate enhancement as a function of solids concentration in the feed is also discussed.

The application of high intensity ultrasound in the solid-liquid suspension would cause the occurrence of cavitation microbubbles in the liquid medium.[3] The cavitation is created at sites of rarefaction as the liquid fractures or tears because of the negative pressure of the sound wave in the liquid. As the wave fronts pass, the cavitations "bubbles" oscillate under the influence of positive pressure, eventually growing to an unstable size. Finally, the violent collapse of the cavitation "bubbles" results in implosions, which cause shock waves to be radiated from the sites of the collapse. The collapse and implosion of myriad cavitation "bubbles" throughout an ultrasonically activated liquid result in the effect commonly associated with ultrasonics. It has been calculated that temperatures in excess of 10,000°F and pressures in excess of 10,000 psi are generated at the implosion sites of cavitation bubbles[6]. Thereby, the mechanical effect of ultrasonic energy can be helpful in displacing particles especially to decrease the thickness of the cake on the filter surface. Indirectly, the reduction of the resistance layer causes and increase in the filtration rate.

MATERIALS AND METHOD

Experimental Rig

One lab scale filter leaf module is developed based on the commercial design as illustrated in Figure. 1. The In-situ ultrasonic wave fields system consists of a pair of 3 transducers attached on each side of the housing wall adjacent to the filtering surface.

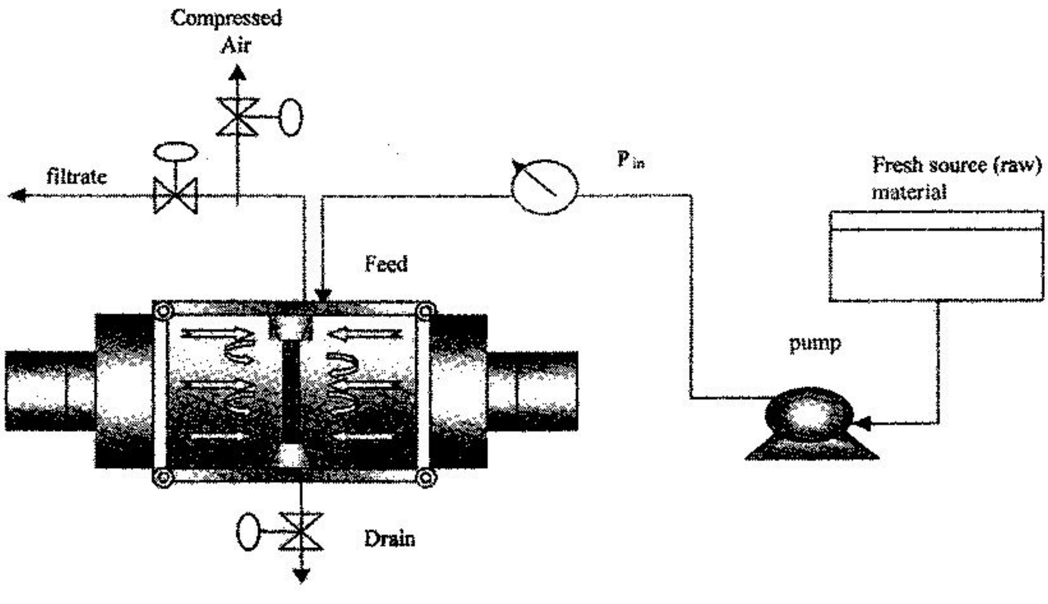

Figure 1: Schematic Diagram of the experimental rig

Parameter Variables

A stainless steel leaf filter with a dimension of 8 inch x 8 inch and a 24 x 110 mesh (140 microns) was used as the filter medium. Suspension of activated clay in RBD oil was used as a feed sample. During the study the concentration of the feed was varied from 10 g/l until 50 g/l. A summary of the operating conditions of the experiments is shown in Table 1.

Variables	Conditions
1) Power (W)	250
2) Frequency (Hz)	40000
3) Operating Pressure (bar)	4 bar (constant)
4) Operating Temperature	27 °C
5) Concentration (g/l)	10,20,30,40,50

Table 1: A summary of the operating conditions of the experiments

RESULTS AND DISCUSSION

Figure 2 shows the typical curve of filtrate flux versus filtration time in the separation of activated clay from RBD oil using a simulated *Niagara* pressure leaf filter. As can be seen, the flux decreased rapidly in the first 10 min of filtration. This is due to the plugging of filter pores which restricts the passage of filtrate through the filter medium. The zone of sharp drop in the flux is followed by a slow but progressive decrease of flux.[5] This is the zone of cake layer formation in which the thickness of the cake progressively thicken as a result of solid depositing on the filter medium following the flow of filtrate passing through the filter.

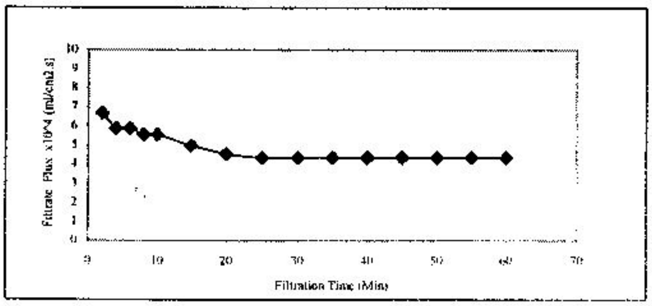

Figure 2: Typical curve of filtrate flow rate versus filtration time in a filtration process

Figure 3 shows the effect of solid concentration on the rate of filtration. As expected, the figure shows that as the solid concentration in the feed was increased the rate of filtration would decreased accordingly. As the solid concentration in the filtration was increased more particles were available in the system. Thereby, a much faster build-up of the cake took place and a higher degree of concentrated layer above the cake was formed which also increased the resistancy of filtrate flow.[4]

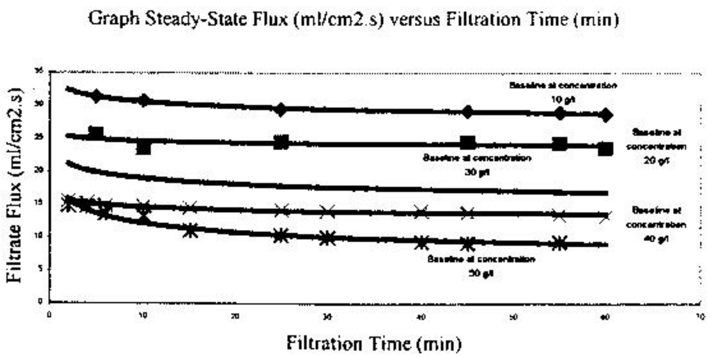

Figure 3 : The effect of solid concentration on the rate of filtration

Figure 4 shows the experiment conducted with application of ultrasound fields intermittently. As observed, as the ultrasound field was exposed to the filter system the flux gradually increased accordingly. The presence of ultrasound fields increases the filtration rate in two ways;

i) decrease the thickness of the cake layer
ii) disrupt the concentrated layer adjacent to the cake layer.

This finding is supported by the fact that as the ultrasound was switched-off the filtration rate dropped drastically, which reflects the reformation of the concentrated layer and the progressive build up of cake layer. The degree of flux improvement as a result of ultrasound application varies in accordance to the feed solid concentration. The effect of ultrasound was more pronounced at lower solid concentration in comparison to the higher solid concentration. The lower effectiveness of ultrasound at higher solid concentration was due to the higher degree of attenuation of the sound wave fields. Thus, a lower effective sound energy that is available for the cleaning of the filter cake.

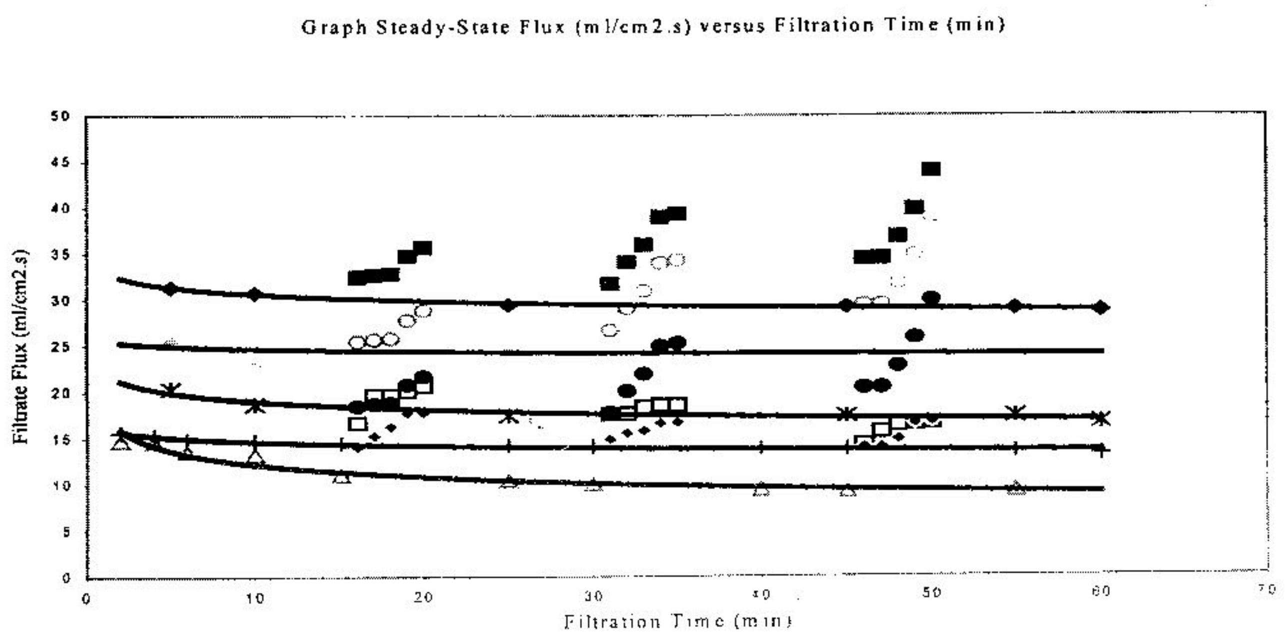

Figure 4: Experiment conducted with application of ultrasound fields intermittently (comparison between 10 g/l ,20 g/l, 30 g/l, 40 g/l, and 50 g/l C with 5 minutes S in 10 minutes filtration cycle)

CONCLUSION

From the study, it can be concluded that the presence of ultrasound wave fields in the filtration of activated clay from RBD oil enhanced the overall filtration process. The degree of flux enhancement was dependent on the solids concentration of the feed suspension. The application of ultrasound field was able to increase the filtration rate by reducing the resistance in the filtrate flow. The reduction in the resistance of filtrate flow was accomplished by:decreasing the thickness of the cake layer and disrupting the concentrated layer adjacent to the cake layer

NOTATION

C = Concentration

S = Sonication

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